Remarks:

1. Applicant appreciates Examiner's careful examination of the present application. At the time of examination, claims 1 – 10, as renumbered by Examiner, were pending. Claims 1 – 10 were rejected by Examiner under 35 U.S.C. § 102(b) and 35 U.S.C. § 103(a).

2. **Amended Claims:** Claim 1 was amended to recited a fluent control valve for supersonic flow, and language was added defining the flow path as having a converging section that leads directly into a diverging section. [Underlined text inserted.] The converging section and diverging section are shown in FIG. 4B, as originally filed. The converging section is the section of the flowpath from the outer edge of the fluent-control plate **101** in toward the throat region **105**, and is discussed in paragraphs [0012], [0013], [0045] and [0046] of the Specification as originally filed.. The diverging section is shown clearly in **FIG. 4B**. Claim 2 was amended to recite a radiused nozzle-inlet edge that is between the converging section and the diverging section and that the fluent-control plate closes against said nozzle plate above the radiused nozzle-inlet edge. This language is clearly supported by **FIGS. 4B. 5A – 5C**, and **6**, which show the fluent-control plate above the nozzle plate. The geometries are such that the fluent-control plate, when closed against the nozzle plate, must be above the radiused nozzle-inlet edge. These amendments introduce no new subject matter and Applicant requests approval and entry of these amended claims.

3. **Supersonic Thrust Valve:** Before discussing the rejections, a brief discussion of the particular conditions of supersonic flow is deemed helpful.. A supersonic nozzle is made up of two sections, a converging flow section and a diverging flow section. Flow is subsonic in the converging section and supersonic in the diverging section. The transition from subsonic to supersonic flow occurs under conditions of sufficiently high pressure on converging flow with increasing velocity. Intuition and previous teachings taught that the normal shock wave would set up as the direction of flow turned 90

degrees, that is, where the flow entered the diverging section of the nozzle. Studies and experiments by the inventor have shown that this is not the case. The shock wave actually sets up at the throat, that location where the flow area is the smallest. The location of the throat varies slightly as the valve opens and closes and is referred to in the Detailed Description of the present application as the "throat region **105**". The throat shall be referred hereinafter to as "geometric throat," simply to emphasize that the "throat" refers to the smallest area of flow.

4. There are two major problems that occur with conventional supersonic flow valves. First, the tremendous amount of heat in the fluid up to the point where the flow turns supersonic causes serious material ablation and erosion on the nozzles. This is because, with the conventional supersonic valve, the normal shock wave sets up right at the nozzle inlet, where there is very little material to absorb heat. The loss of material at the edge of the nozzle inlet changes the geometry of the valve, resulting in loss of efficiency of the nozzle. Second, flow tends to separate from the walls when it flows into the diverging section of the nozzle. Separation leads to turbulence, which, in turn, results in dissipation of kinetic energy, effectively reducing the thrust work from the flow.

5. The radiused nozzle inlet of the FCV of the present application is carefully designed to control the flow so that the normal shock wave resulting at the transition from subsonic to supersonic flow sets up at a place where a significant mass of material is available to absorb heat energy from the extremely high temperature of the fluid, thereby eliminating or significantly reducing the risk of ablation or erosion. It is an inventive feature of the FCV of the present application to control supersonic flow such that the shock wave sets up above, that is, upstream of the diverging flow section, *i.e.*, the nozzle. Thus, the shock wave sets up at a place where the flow is still essentially horizontal across the nozzle plate and where a large mass of material is available to absorb heat energy. The nozzle inlet and the geometric throat are not one and the same in the valve of the present invention. The nozzle inlet, or divergent section of the

nozzle, begins at the radius. The geometric throat is upstream of the radius when the valve is less that 100% open and snaps to a location downstream of the radius when the valve opens 100%. The temperature and pressure of the fluid are greatest in the subsonic flow just before the normal shock wave, and are significantly lower in the supersonic flow downstream of the normal shock wave. Thus, the walls of the nozzle in contact with the fluid at the site of the normal shock wave are subjected to extremely high temperatures and high heat flux.

6. It is a further inventive feature of the FCV to control the flow so that the transition from subsonic to supersonic is gradual, rather than sudden, thereby reducing to a minimum undesirable flow separation and the resulting turbulence and loss of performance. If the diverging section expands too quickly, flow separation occurs and thrust performance is diminished. With the FCV, at conditions less than 100% open, the inlet radius is downstream of the geometric throat, the point where the normal shock wave occurs. Hence, the radius is in the supersonic flow region and provides a gradual controlled expansion as the flow turns into the orifice. In the valve according to the present invention, the radius of the nozzle both controls the location of the shock wave and minimizes flow separation. The radiused wall going into the nozzle inlet enhances the valve characteristics by reducing separation losses, and preventing ablation and erosion of the nozzle inlet material.

7. **Rejection under 35 U.S.C. § 102(b):** Examiner rejected claims 1 and 3 – 10 under 35 U.S.C. § 102(b) as being anticipated by **Feild et al. (U.S. Patent 3,975,116).** Examiner asserts that the **Feild et al.** citation discloses a valve that has all the elements of the valve claimed in the present invention and, thus, must perform in the same manner, including forming a hydrodynamic fluid pintle.

8. The **Feild et al.** valve has a converging section, a straight section, and a diverging section. The transition from the converging section to the straight section is an abrupt 90-degree turn from horizontal to vertical flow. At operating conditions less

than 100% open, the geometric throat and the nozzle inlet are one and the same in this valve. Knowing that the normal shock wave sets up at the geometric throat at supersonic flow, it is clear that, when the valve is less than 100% open, the normal shock wave and, thus, the greatest heat flux, will set up right at the throat, that is, right at the 90 degree edge at the nozzle inlet. The throat or nozzle inlet is just a small tip of material with a high surface area and a small volume of material. Under supersonic flow conditions, the heat flux, temperature, pressure are greatest at the tip and will most certainly cause the nozzle material to melt or erode, which then changes the characteristics of the valve and its performance.

9. The change of direction of the fluid at the geometric throat of the **Feild et al.** valve is also abrupt and uncontrolled. The sudden drop from horizontal to vertical causes flow separation and turbulence. This flow separation results in dissipation of flow energy and, consequently, in reduced thrust through the valve.

10. The **Feild et al.** valve has a straight section between the converging section and the diverging section. This straight section introduces drag and significantly reduces the efficiency of a thrust valve, but it is a subsonic flow section that acts as an isolator, the purpose of which is to reduce the turbulence that is created when the fluid make the 90-degree turn at the nozzle inlet and to calm the flow before it exits the nozzle in order to reduce performance loss due to turbulence. The need to have this straight section is an indication that flow separation in a valve with just the converging and diverging sections would introduce unacceptably heavy performance losses.

11. Amended claim 1 recites a flowpath that includes a converging section that leads directly into a diverging section. The **Feild et al.** valve has a converging section that leads into a straight section, and thus, does not anticipate the valve of the present invention. Applicant respectfully submits that amended claim 1 and all claims dependent from it contain allowable subject matter and requests that Examiner withdraw his rejection under 35 U.S.C. § 102(b) of claim 1 and its dependent claims 3 –

10 and allow these claims.

12. **Rejection under 35 U.S.C. § 103(a):** Examiner rejected claim 2 under 35 U.S.C. § 103(a) as being unpatentable over **Feild et al.** in view of **Long et al. (2003/0062495)** and **Carillo et al. (2002/0117644)**. Examiner asserts that Long et al. and **Carillo et al.** disclose radiused nozzle inlets with an outlet nozzle flare. Both **Long et al.** and **Carillo et al.** valves are traditional pintle valves, with a narrow tip at the lower end of a pintle or plug. This type of valve and its disadvantages are discussed at length at paragraphs [004] – [007] and in [0041] – [0043] and shown in FIGS. 2A – 3C in the Specification of the present application. Please see particularly FIGS. 2A and 3A of the present application, which show pintle valves at 50% and 90% open, respectively, and show that high temperatures occur right at the very tip of the pintle, which is consequently subject to ablation and melting away.

13. The radiused nozzle-inlet edge that Examiner refers to with reference to **Long et al.** and **Carillo et al.** (Long, at 32) <u>is a converging section</u> and not a radiused nozzle-inlet edge. The edges leading into 32 are not radiused, but are machined at an angle relative to the horizontal surface. See FIGS. 1 and 2 in **Long et al.** and FIGS. 1 – 3 of **Carillo et al.** The key difference to the valve of the present application is that the pintle or plug in both cited references closes the flow path by moving down into the converging section and seating against the sides of the converging section. Amended claim 2 now includes language that the fluent-control plate closes <u>above</u> the radiused nozzle-inlet edge. This is not the case for each of these cited references.

14. It is noted that claim 2 depends from claim 1 and includes the subject matter of claim 1. **Feild et al.**, **Long et al.**, and **Carillo et al.**, either alone or in any combination, do not teach, disclose or motivate one to construct a fluent control valve as claimed in claim 1 or as claimed in claim 2. Applicant respectfully submits that claim 2 is not rendered obvious by the cited references **Feild et al., Long et al.**, and **Carillo et al.**, and accordingly requests that Examiner withdraw his rejection of claim 2 and allow this

claim.

15. Applicant amended claims 1 and 2. Each and every rejection raised by Examiner has been successfully traversed. The amended claims and all dependent claims contain allowable subject matter. Applicant requests allowance of claims 1 – 10.

16. This paper is being filed within the six months of the date of the Office Action. A Petition for Extension of Time and authorization for payment of the appropriate late fees are included with the submission of this paper.

Respectfully submitted,

Patricia M. Mathers

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Petition for Extension of Time

Patricia M. Mathers
Attorney for Applicants
Reg. No. 44,906
Bohan, Mathers & Associates, LLC
P. O. Box 17707
Portland, ME 04112-8707
(207) 773-3132